

## **Paraguayan bats of the genus *Myotis*, with a redefinition of *M. simus* (Thomas, 1901)**

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**Paraguayan bats of the genus *Myotis*, with a redefinition of *M. simus* (Thomas, 1901).** - Based on measurements and odontology taken from more than 180 specimens of *Myotis* spp. from Paraguay and nearby areas of Argentina and Brazil, the systematics of members of this genus is reviewed. Four species are found in Paraguay : *M. nigricans*, *albescens*, *levis* and *ruber*. *M. simus* auct. from Bolivia to Argentina in fact refers to various other species; it is not found within the borders of Paraguay. This species, i. e. *M. simus*, is easily recognizable and seems to be restricted to the Amazon basin.

**Key-words:** Chiroptera - *Myotis* - Odontology - Taxonomy - *M. simus* - Paraguay.

### **I - INTRODUCTION**

Since 1979 the Muséum d'Histoire Naturelle de Genève (MHNG) has had the opportunity to study the fauna of Paraguay in collaboration with the Ministry of Forest and Agriculture. During various expeditions we collected more than ten genera of bats; two of them are new for Paraguay: *Phyllostomus hastatus* and *Macrophyllum macrophyllum* (BAUD 1981 and 1989).

However, the identification of *Myotis* spp. is difficult, and the systematics of some taxa is open to question. The more numerous the captures, the more difficult was the separation at the specific level based on literature records for this country (MYERS 1977, MYERS & WETZEL 1979, 1983). For this reason we adopted two different ways of investigations; one of us identified the specimens using standard measurements, whereas the other one - independently ("blind method") - relied on odontological features.

## MATERIAL AND METHOD

One hundred and eighty specimens were randomly selected for this study; this material originates from all localities of Paraguay visited during our various field trips (Fig. 1). We included, however, all individuals with peculiarities in coloration as well as the larger ones. Two collections from Argentina, i. e. 20 specimens from Eldorado (Misiones) and 11 individuals from Ituzaingo (Corrientes), and one of 12 bats from Nova Teutonia (Santa Catarina) in Brazil were included for comparison.

Extracted skulls were known only by their field number. The two authors, each one using his own method, compared the identifications afterwards.



FIG. 1

Map of collecting localities in Paraguay.

## 1. STANDARD MEASUREMENTS EXPRESSED BY MEANS OF INDEXES

After several attempts, we found that the best way to represent the morphology of the skull by numerical data is expressed by the "Maxillary Index" (MXI) and the "Cranial Index" (CRI). These indexes are defined by the following formulae:

$$\text{MXI} = \frac{(\text{CC} + \text{MM})}{2} \text{CM}^3$$

$$\text{CRI} = \frac{(\text{POC} + \text{LC})}{2} \text{GLS}$$

CC = greatest external breadth at the upper canines

MM = greatest external breadth at the upper molars

CM<sup>3</sup> = perpendicular distance between the posterior tangent at the level of the last molars and the anterior tangent of CC

POC = post-orbital constriction

LC = breadth of the brain case

GLS = greatest length of the skull in front of the incisives.

All measurements were made with a Nikon V-12 profile projector, permitting to measure at 1/1000 mm. We measured at 1/100 mm precision and rounded to the upper or lower unity at 1/10th of millimeter. This method allows to avoid calculation errors.

## 2. ODONTOLOGY

We adopted the odontological characters defined in the "Etude des morphotypes dentaires des Vespertilionidae" (MENU 1985, 1987)<sup>1</sup>. The nomenclature is that of VAN VALEN (1966) with some modifications.

## RESULTS

### 1. MEASUREMENTS AND INDEXES (see table I and II and Fig. 2)

It is obvious that more than 90 % of the 181 individuals examined, have a MXI of 20 and 25,5 for both sexes. Due to the fact that the components of this index overlap, it is not useful to distinguish the various species. The CRI of this series, however, permits the separation of two clearly distinct groups, i.e. I and II, the first ranging from 63 to 73,8 and the second one from 75,5 to 85,7.

Two more clusters are clearly recognized: the first with a CRI ranging from 86,6 to 88 and a MXI between 25,8 and 26,4 (3 bats), the second (5 specimens) with values between 79,8 to 82,6 (CRI) and 29,2 to 31,1 (MXI), respectively. We call them group III and IV.

### 2. ODONTOLOGY

Concerning the dentition, group I to IV belong to the "*Leuconoe*" type (Cf. MENU 1987) but in the case of the IV th group some peculiarities in various features

<sup>1</sup> In the present paper the term "*Leuconoe*" is used in a morphological context and does not refer to the nomenclature (cf. MENU 1987).

TABLE I

Maximum and minimum of standard measurements of the Paraguayan *Myotis*.  
(Here, the results are not rounded to the upper or lower unit)

Gr. Specie	Forearm	GLS	CM <sup>3</sup>	POC	C-C	M-M	LC
I <i>M. nigricans</i> (n = 77)	30,90	13,10	4,80	3,30	3,21	5,08	6,12
	36,00	14,20	5,40	3,65	3,68	5,57	6,89
II <i>M. albescens</i> (n = 95)	33,70	13,58	4,72	3,61	3,44	5,06	7,01
	37,80	14,89	5,36	4,35	3,93	5,61	7,54
III <i>M. levis</i> (n = 3)	36,50	14,87	5,40	4,05	3,84	5,54	7,44
	38,20	15,15	5,45	4,21	3,97	5,81	7,64
IV <i>M. ruber</i> (n = 5)	40,10	15,17	5,86	3,52	4,04	5,89	7,00
	41,10	15,36	6,04	3,69	4,24	6,04	7,10

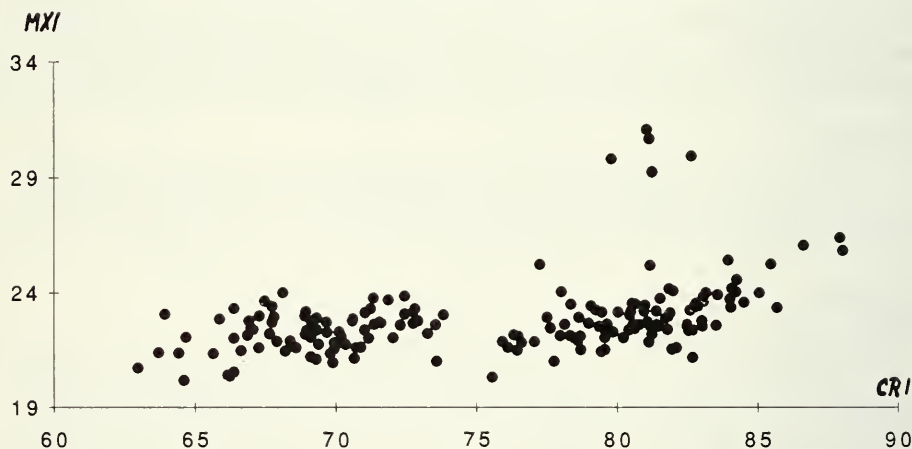


FIG. 2.

Cranial (CRI) and maxillary (MXI) indexes of *Myotis* spp. from Paraguay.

TABLE II

Maximum and minimum of calculated Maxillary and Cranial Indexes

	<i>M. nigricans</i>	<i>M. albescens</i>	<i>M. levis</i>	<i>M. ruber</i>
MXI	20,193	20,343	25,820	29,241
	24,030	25,424	26,405	31,076
CRI	62,989	75,573	86,612	79,794
	73,829	85,682	88,022	82,637

are found (see conclusions). For group I to III the morphological characters (Fig. 3 and MENU 1985) are:

- I<sup>1</sup> E-type and I<sup>2</sup> A-type.
- Upper canine A type. The values calculated by the depth of C and P<sup>4</sup> are similar to those of European species including, e. g., *M. daubentoni* and *nattereri*; no increasing processus is found for C.
- P<sup>2</sup> and P<sup>3</sup>: all populations usually show the typical reduction observed in many *Myotis* spp.; even lingual occlusion of P<sup>3</sup> (often crowned) cannot be considered to be a distinctive character at the specific level.
- P<sup>4</sup> A-type, with antero-lingual cingular cuspid. The distal border is concave, but without indentation: this characteristic is important, and generally stable in European forms in which it is useful to separate *daubentoni* from *cappaccinii*.
- M<sup>1</sup> and M<sup>2</sup> A-type. The protofossa is closed posteriorly, the metaconul is reduced in size; the postprotocrista is declivous and only slightly deviated at the connection with the metaloph. The latter feature directs to the anterior point of the tooth and turns around the crest of the metaconul from inside. The paraloph is strong and elicits an inflexion of the fore-protocrista, imitating a residual paraconul.
- M<sup>3</sup> is A-type (Fig 35 in MENU 1985). It is on the way towards a more evolved morphology. The metacone is not voluminous and does not form a pertinent distal protuberance.
- As in all "*Leuconoe*", the morphology of the mandibular tooththrows is virtually identical. Apart from the dimensions, they do not permit to separate the species.

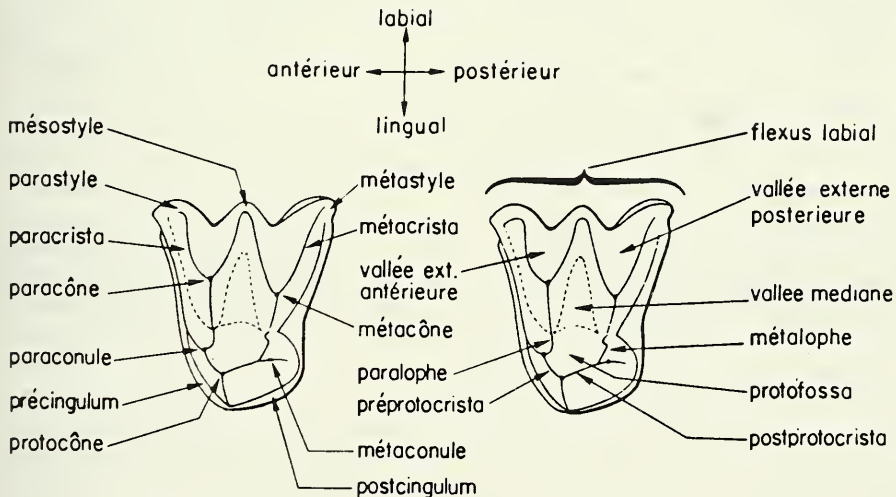


FIG. 3

Descriptive terminology of the upper molars of Vespertilioninae (MENU 1985).



However, the homogeneity of the mandibular teeth is an important character in defining the genus.

## CONCLUSIONS

Our results show clearly that the groups I to III are identical as to the odontology; they differ only in their dimensions (Fig.4 a-c). There can be no doubt that these groups belong to the genus *Myotis*. Incidentally, colouration is not a useful character in distinguishing the various species because this feature depends on subjective criteria of the observer, varies seasonally, and depends on the state of conservation of the skin. Therefore, we propose the following identifications:

– *Myotis nigricans* (Schinz, 1821) for group I. This is a small uniformly black or deep brown species. The type locality lies between Itapemirim and the Río Iconha (Espírito Santo) on the eastern coast of Brazil, at about the same latitude as northern Paraguay. It is a well known species widely distributed over South America and ranging southward to northern Argentina (KOOPMANN 1982).

– *Myotis albescent* (E. Geoffroy, 1806) for group II. This species was described from "... la estancia de San Solano, junto al estero de Ibera"; at the time of the original description, this locality was in Paraguay; nowadays, this place lies within Argentina's borders. LAVAL (1973) designated a neotype coming from Yaguaron (Paraguari) in Paraguay. This small to medium sized species differs in colouration from *M. nigricans* only by its lighter underparts and a slightly "frosty" aspect of his back. The distribution is identical with that of *nigricans*.

– *Myotis levis* (E. Geoffroy, 1824) for group III. The third group is less clearly separable when the forearm length is used; the values range from 36,5 to 38,2 mm and overlap with the data of the preceding species. Therefore, this character is not useful to separate it from Paraguayan *M. albescent*. Moreover, our data set is highly limited because we had only three specimens on hand: one from Paraguay and two from El Dorado (Misiones), Argentina. The MXI and CRI, however, are within the limits of some *Myotis levis* (E. Geoffroy, 1824) deposited in the British Museum (BAUD 1979) and also within the limits of the data of the same species from Uruguay examined by LAVAL (MXI = 26,8 and CRI = 87,9). *M. levis* lacks the precise type locality, the author giving just "South Brazil" as the origin of this bat. To this day, it is known from southern Brazil, Uruguay and the northeastern corner of Argentina. This makes it highly probable that this species also occurs in Paraguay, and we do not hesitate to assign to *M. levis* the specimen from west of the Río Parana, at the edge of the Río Pirayu-i (Itapua). It appears to be the first record for this country.

– *Myotis ruber* (E. Geoffroy, 1806) for group IV. As we stated above, group IV differs from the remaining groups in MXI and CRI as well as in the morphology of some of its teeth (Fig. 4 d). The P<sup>4</sup> has a rectilinear posterior border, i. e. it is neither concave nor indented. The metacone of the M<sup>3</sup> is only slightly developed, and its basis protrudes only moderately distally. Based on colour pattern which is cinnamon-rufous in all specimens examined, we allocate them to *Myotis ruber* (E. Geoffroy, 1806). This species was described from Paraguay; likewise, the neotype designated by LAVAL (1973) comes from Sapucay (Paraguari). Two specimens were captured at Salto Tembey on the Río Pirayu-i (Itapua) and three are from Nova Teutonia in Santa-Catarina province of Brazil.

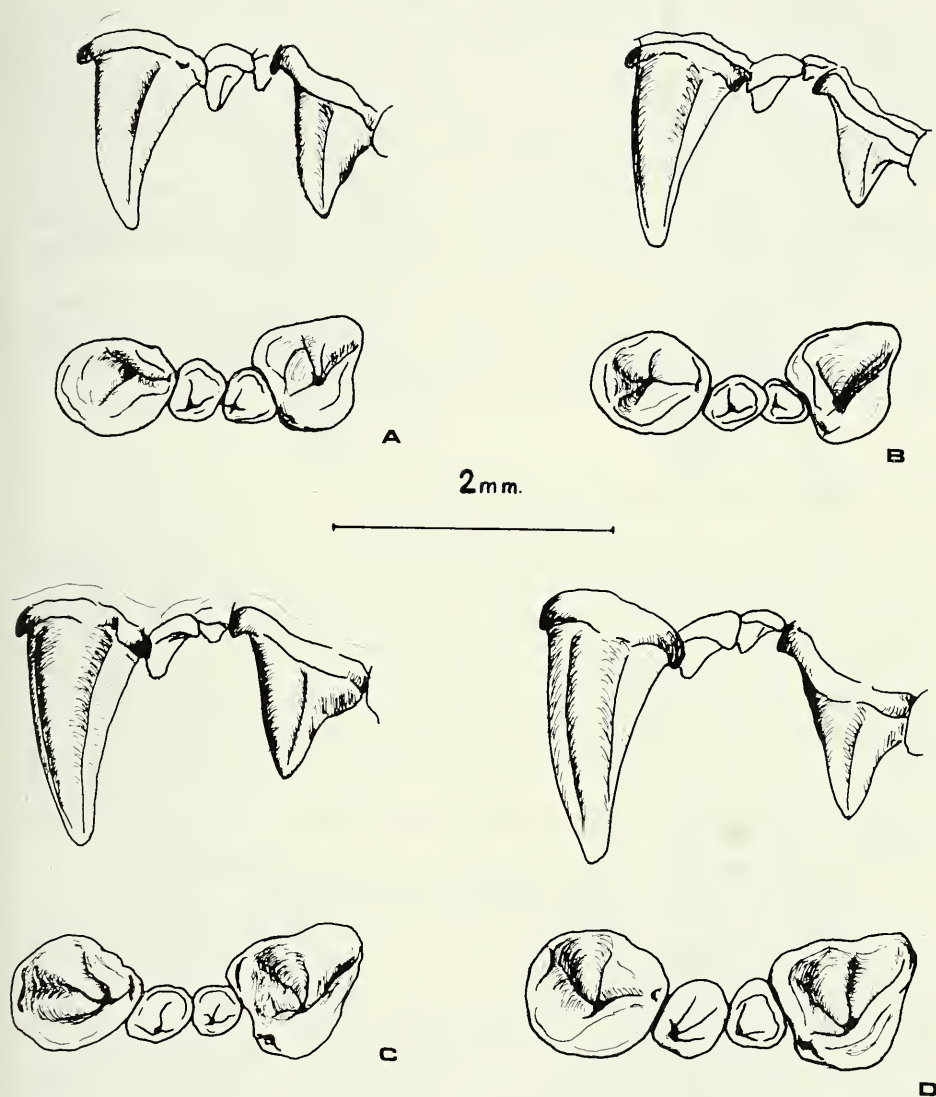


FIG. 4

Occlusal and labial view of the left upper toothrow in Paraguayan *Myotis* (without molars).  
a.- *M. nigricans*; b.- *M. albescentis*; c.- *M. levis*; d.- *M. ruber*.

Contrary to our initial expectation, there seems to be only four species of *Myotis* found in Paraguay. Using the data given by WETZEL & LOVETT (1974) and MYERS (1977), BAUD (1981) identified a specimen from the Río Apa region as *M. riparius* (Handley, 1960); in fact, the data of this individual are within the limits of *M. nigricans*. We examined two bats deposited in the Museum of Vertebrate Zoology at Berkeley collected by the American authors and originally identified as *riparius*; one represents *nigricans*, the second belongs to the *albescens*-group.

The same institution kindly loaned us two other *Myotis* from Paraguay identified as *simus* and cited by WETZEL, LOWETT & MYERS in their respective papers. MYERS first labeled them as *M. ruber*. Based on the two cranial indexes, odontology and colouration, it seems to us that this determination was correct.

MILLER & ALLEN (1928) and LAVAL (1973) consider *Myotis simus* (Thomas, 1901) to be a strictly Amazonian species. We do not understand why this species should have penetrated suddenly as far south as Paraguay and northern Argentina (FORNES 1972) after 1960 ?.... This leads us to the second part of our work.

## II. - REDIFINITION OF *Myotis simus* (Thomas, 1901)

According to Thomas' description there are several differences between *M. simus* and all other species of this genus, among which the following character: "Wings attached to the ankle...". Moreover, in their monograph on the American *Myotis*, MILLER & ALLEN emphasize on this character and add: "The canines, in particular, are larger than those of other South American species." These authors gave two types of colouration, i. e. "red ... nearly the ochraceous-tawny of RIDGWAY, slightly paler, approaching yellow-ocher on the underparts..." being the more frequent, or "...brown...nearly Mars-brown, the underparts with a slight ochraceous cast ..."

Concerning the composition of these colours, RIDGWAY (1886) defined them as follows:

"Ochraceous-tawny" = burnt sienna + burnt umber + yellow ochre

"Mars-brown" = burnt umber + yellow ochre + burnt sienna.

It turns out that these colours are in fact very close to each other, differing only in the proportions of their components.

Based on the original description of *M. ruber* and on MILLER & ALLEN in the same monograph, it becomes evident that this species is most similar - the dentition excepted- as to colouration, being either "ochraceous-tawny" or "Mummy-brown" (= raw umber + burnt sienna); the dark phase is mixed up with "Prout's-brown" (= raw umber + burnt umber + sepia). We came to realize that these faint differences are in fact purely subjective and depend only on the conditions of preservation. It is a well known phenomenon that "foxing" or decolouration of the skins in alcohol affects the colours of all museum specimens within a short time. Therefore, colour characters are not considered to be an "a priori" systematic criterion to us, although all living and preserved *M. ruber* we had on hand were "Cinnamon-rufous" whereas all *simus* we have seen are "Mummy-brown" and never ochraceous; this last observation concerns specimens stored in alcohol during three weeks only as well as old material (dry skins) in the American Museum.



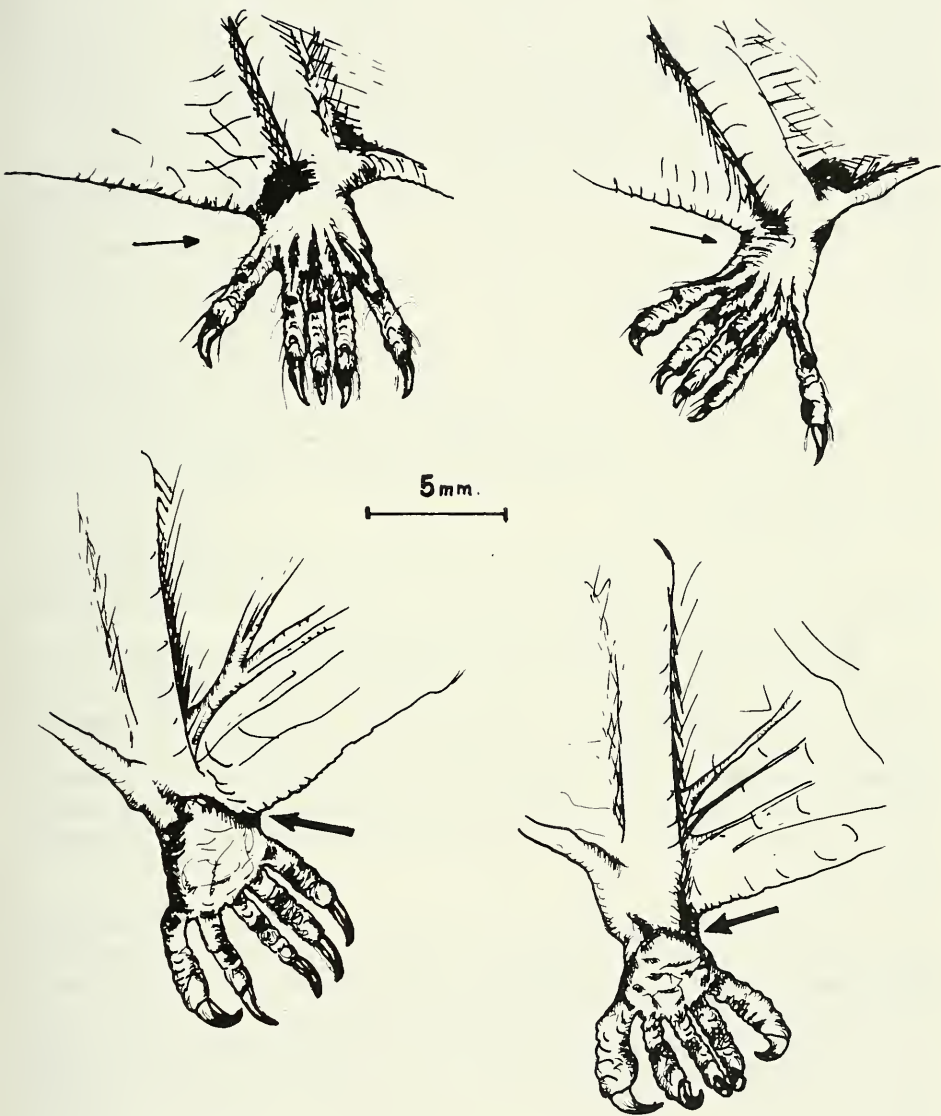


FIG. 5

Dorsal and ventral view of wing insertion in *Myotis ruber* (left) and *M. simus* (right).

What about the morphology and in particular the attachement of the wing to the ankle, an important character of THOMAS' diagnosis? Incidentally, HANDLEY (1960), in his description of *M. simus riparius* - further *M. riparius* - says that "...the supposed insertion of the wing at the ankle..." of *simus* is "...an artefact", and that "...actually the wing is attached to the base of the toes as in most *Myotis*." This firm statement was accepted by all subsequent authors including LAVAL (1973). As a consequence they considered this "detail" to be a negligible feature. At the same time this explains why *M. simus* is reported from South America as far as Argentina...!

In 1980, our colleague of the MHNG, Dr. C. Vaucher, collected two bats of the genus *Myotis* at Samiria on the Río Samiria (Dept. of Loreto) in Peru, about 100 km north of the type locality of *simus*: Sarayacu, situated in the Upper Peruvian Amazon (Río Ucayali). The examination of the foot leaves no doubt that the attachment of the wing is at the ankle, leaving the foot free, in agreement with Thomas' description (Fig.5).

Upon written request on the condition of this character in the type specimen of *simus* (BMNH 8.5.12.2, adult ♀, in alcohol), Dr.P.D. Jenkins of the British Museum replied: "... the foot is free". To bring more light to this problem, we borrowed two specimens from the American Museum (AMNH 71 485-86) that formed part of the series examined by MILLER & ALLEN. In both individuals the wing is inserted at the ankle. This peculiarity is characteristic for this species, and separates *simus* from all other Neotropical *Myotis* spp.

Another character of *M. simus*, emphasized by MILLER & ALLEN is the unusual size of the upper canine in its length as well as in its basal section. This, however, is not due to geographical variation as supposed by HANDLEY, but probably represents an evolutionary trend found in South American endemics.

Odontologically, the reduction of the distance C-P<sup>4</sup> has several consequences: a regression of P<sup>2</sup> and especially P<sup>3</sup>, with a considerable lingual removal of the two teeth (Fig.6). Most specimens exhibit a crowding of P<sup>3</sup>, in a way that P<sup>2</sup> seems to be in contact with P<sup>4</sup>. The fourth upper premolar is characterized by a conspicuous indentation at the distal border, forming a striking inner lobe (postero-lingual heel). The antero-lingual singular cuspid is missing : this is a highly constant specific character in some Palearctic species as for instance *Myotis nattereri*, *M. emarginatus* and *M. cappaccinii*. But the general aspect of P<sup>4</sup> is referable to the B-type (MENU 1985, p. 104).

M<sup>1</sup> and M<sup>2</sup> are of the A type, i. e. in evolution. They show a strong metaloppe, directed towards the interior of the protofossa, and permitting the development of a conspicuous metaconule. The M<sup>3</sup> belongs to the A-Type, poorly evolved. Its metacone is voluminous, and the base constitutes the distal projection of the tooth.

The mandibular tooththrow is of the "*Leuconoe*"-type (sensus MENU). The regression of the upper P<sup>2</sup> and P<sup>3</sup> as well as the constriction of the length of C-P<sup>4</sup> have no incidence on the arrangement of the homologous lower teeth.

## CONCLUSION

We found that *Myotis simus* is a highly distinct species. It is easily recognizable and differs from all other South American representatives of the genus by the structure of the upper canine and the insertion of the wings. Our findings do

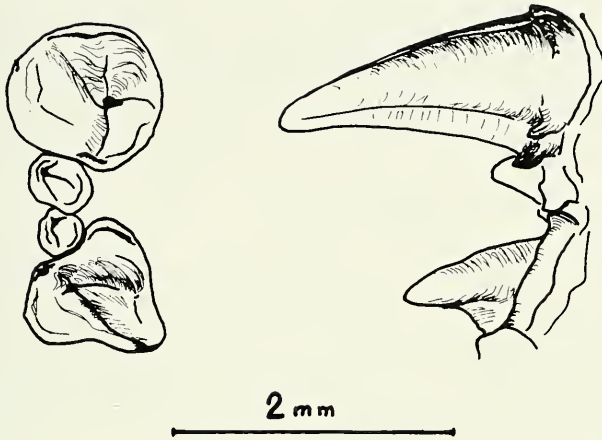


FIG. 6

Occlusal and labial view of the upper toothrow in *Myotis simus* (without molars).

not support its separation as a distinct sub-genus (*Hesperomyotis*) as proposed by CABRERA (1957) on the basis of these characters. Re-examination of all material from outside the Amazon Basin assigned to *M. simus* is recommended in order to get a better idea of the distribution of this species.

#### ACKNOWLEDGMENTS

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#### MATERIAL EXAMINATED (MHNG)

##### *Myotis levis*

Paraguay: -Itapua: Pyrayu-i (1 ♂).

Argentina: -Misiones: El Dorado (2 ♀).

*Myotis ruber*

Paraguay : -Itapua: Rio Tembey (1 ♀); Pyrayu-i (1 ♀).

Brazil : -Santa Catarina: Nova Teutonia (3 ♀).

*Myotis albescens*

Paraguay : -Concepcion: Rio Tagatya-Guazù (1 ♂/2 ♀); Estancia Santa Sofia (1 ♂); Estancia Primavera (1 ♀). - San Pedro: San Pedro, Rio Jejui-Guazù (4 ♂/14 ♀). - Presidente Hayes: Trans Chaco, km 170, Estero Patino (1 ♂/1 ♀); Rio Aguaray-Guazù (1 ♂/4 ♀); Trans Chaco, Rio Verde (7 ♂/19 ♀); Trans Chaco, Monte Lindo (4 ♂/2 ♀); Rio Salado, north Pozo Colorado (1 ♂); Trans Chaco, km 293, Estancia Apendice (1 ♂). - Cordillera: north Emboscada, Rio Piribebuy (1 ♂). - Alto Parana: Itakyry (2 ♂/4 ♀); Taty Yupi, Itaipu (1 ♂). - Caazapa: Yegros, Rio Pirapo (2 ♀). - Alto Paraguay: General Diaz (1 ♂). - Caaguazù: Rio Yucuyry, south Yhù (1 ♂).

Argentina : - Misiones: El Dorado (2 ♂/16 ♀).

Brazil : - Santa Catarina: Nova Teutonia (1 ♂).

*Myotis nigricans*

Paraguay : - Concepcion: Estancia San Luis (1 ♂); Arroyo Alegre, Estancia Primavera (2 ♀); Estancia Santa Sofia (3 ♂/6 ♀); 25 km south Estancia Estrella (1 ♂/2 ♀); Rio Aquidaban-Rio Paraguay (4 ♂/1 ♀); Rio Trementina, Laguna Negra (1 ♂); Arroyo Azotey, north Cororo (1 ♂). - Presidente Hayes: Estancia Apendice (2 ♂/4 ♀); Rio Aguaray (1 ♂/11 ♀); Trans Chaco, Rio Verde (4 ♂/5 ♀); Rio Salado, north Pozo Colorado (1 ♀). - Guaira: Numi, Arroyo Yaca-Mi (3 ♂). - Itapua: San Benito (4 ♀). - Boqueron: Estancia La Conquista, Pratt Gill (1 ♂).

Argentina : - Corrientes: Ituzaingo (11 ♀).

Brazil : - Santa Catarina: Nova Teutonia (5 ♂/3 ♀)

*Myotis simus*

Peru : - Samiria, Rio Samiria, Station Pithecia (2 ♂), MHNG 1694.41-42.

## OTHER MATERIAL

Paraguay : - Presidente Hayes: Trans Chaco, 275 km NW Villa Hayes (1 ♂, MVZ 144758, "*M. riparius*" = *M. nigricans*); Trans Chaco, km 205 -20 km SW, Retiro Mandeyù (1 ♀, MVZ 144676, "*M. riparius*" = *M. albescens*); Trans Chaco, 230 km NW Villa Hayes (2 ♀, MVZ 144483-4, "*M. simus*" = *M. ruber*). - Alto Parana: Taty Yupi (1 ♂ IRSNB, *M. albescens*)

*M. ruber*

Paraguay : - Paraguari: Sapucay (2 ♀, BMNH 2.11.7.19 and 2.11.7.1).

Uruguay : - Aroyo Grande (1 ♂/1 ♀, MHNG).

Brazil : - Quebrangulo, Alagoas (1 ♂, MHNG).

*M. levis*

Brazil : - Palmeiras, Parana (2 ♂/1 ♀/1 ind, BMNH 0.6.29.21-24).

Argentina : - Los Ingleses, Ajo General Laval, Buenos Aires (1 ♀, BMNH 9.12.1.67).

Uruguay : - sans origine (2 ♀, BMNH 29.3.17.12-13)

*M. simus*

Peru : - Sarayacu, type specimen (female alcohol, BMNH 81.5.12.2)

Ecuador : - Boca del Rio Curaray (1 ♂/1 ♀, AMNH 71484-6).

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